Appendix I

Cost Analysis - Basis for Calculations

I. Capital Cost Estimates of Diesel Emission Controls and Purchase of New Engines

The estimated capital costs ($/hp) for installation of a DPF was derived from actual costs for DPF installations in California. Table I-1 lists 16 of the 49 known installations of DPFs on emergency generators in California. These 16 were chosen because cost information was available. Most of this information was used to develop equations relating the size of the generator to the cost of the DPF. However, four of these 16 installations (indicated in italics in Table I-1 below) were not used in the development of the equations due to questionable cost data, or because the cost included additional equipment not related to the DPF. Table I-2 lists the 12 emergency diesel engines with a DPF actually used to relate engine size to DPF costs. Figures I-1 graphically represents this relationship and the resulting trend line and equation in terms of total DPF costs and installation costs. These equations are used to calculate the values presented in Chapter IX, Tables IX-4, IX-5, IX-9, IX-11, IX-13, IX-14, and IX-16.

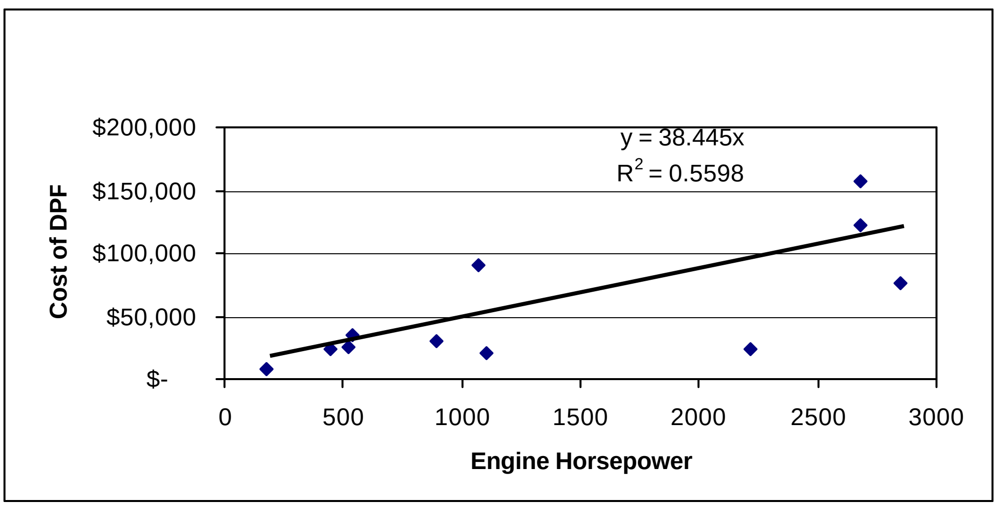
Table I-1: List of Emergency Generators with Installed Diesel Particulate Filters and Available Cost Information

Obs	Facility Type	Engine			DPF			Engine Price
		Make	Model	HP	Age	Capital	Install	
1	Public Works	Caterpillar	3516B	2848	2001	$ 76,000		$317,002
2	Medical Center	Caterpillar		2680	2001	$121,750	$ 35,000	$616,250
3	Candy Company	Caterpillar	3516 B	2680	2001	$ 74,500	$ 47,000	$288,000
4	*Communication*	*Caterpillar*	*3516*	*2479*	*1993*	*$100,000*		
5	*Communication*	*Caterpillar*	*3516*	*2479*	*1993*	*$100,000*		
6	*Communication*	*Caterpillar*	*3516*	*2479*	*1993*	*$100,000*		
7	Data	Cummins	KTTA 50-G2	2220	1997	$ 24,000		
8	*Communication*	*Cummins*	*KTA50-G9*	*2200*	*2001*	*$ 10,000*		
9	Brewery	Caterpillar	3412 DISTA	1100	1999	$ 20,000		
10	Data	Caterpillar		1072	2001	$ 90,000		
11	Communication	Caterpillar	3412C	896	2000	$ 20,000	$ 10,000	$ 90,000
12	Data	Caterpillar		536	2001	$ 35,000		
13	Medical Center	Caterpillar	3406	519	2002	$ 26,000		
14	Communication	Caterpillar	3406	449	2000	$ 20,000	$ 3,600	$ 50,000
15	Hotel	Caterpillar		175	Soon	$ 8,500		
16	Hotel	Caterpillar		175	Soon	$ 8,500		

Table I-2: List of Emergency Generators with Installed Diesel Particulate Filters and Useful Cost Information

Obs	Facility Type	Engine			DPF			
		Make	Model	HP	Age	Capitol	Install	Total
1	Public Works	Caterpillar	3516B	2848	2001	$ 76,000		$ 76,000
2	Medical Center	Caterpillar		2680	2001	$121,750	$ 35,000	$156,750
3	Candy Company	Caterpillar	3516 B	2680	2001	$ 74,500	$ 47,000	$121,500
7	Data	Cummins	KTTA 50-G2	2220	1997	$ 24,000		$ 24,000
9	Brewery	Caterpillar	3412 DISTA	1100	1999	$ 20,000		$ 20,000
10	Data	Caterpillar		1072	2001	$ 90,000		$ 90,000
11	Communication	Caterpillar	3412C	896	2000	$ 20,000	$ 10,000	$ 30,000
12	Data	Caterpillar		536	2001	$ 35,000		$ 35,000
13	Medical Center	Caterpillar	3406	519	2002	$ 26,000		$ 26,000
14	Communication	Caterpillar	3406	449	2000	$ 20,000	$ 3,600	$ 23,600
15	Hotel	Caterpillar		175	Soon	$ 8,500		$ 8,500
16	Hotel	Caterpillar		175	Soon	$ 8,500		$ 8,500

Figure I-1: Existing California DPF Total Costs



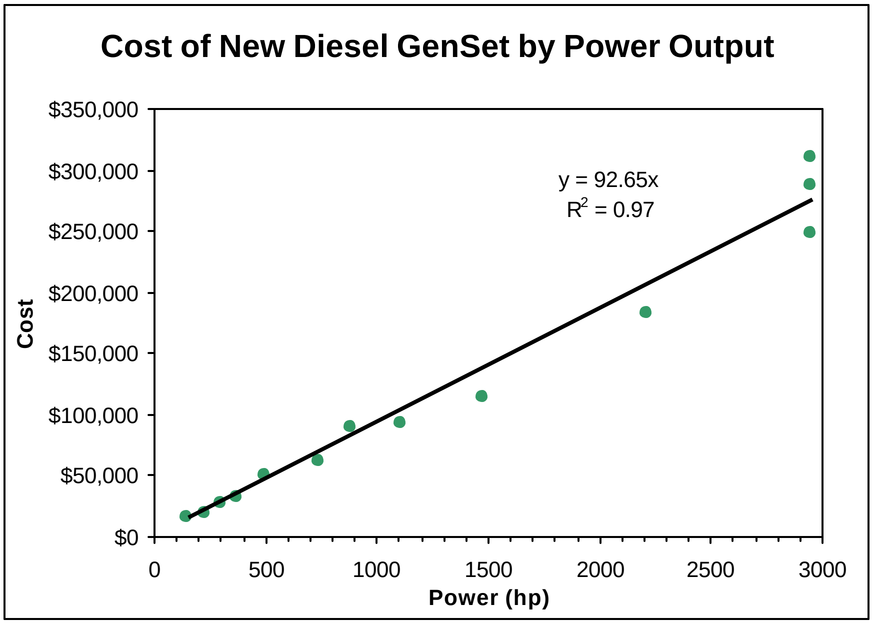
Based on this regression, we estimate the costs for DPFs to be approximately $38 dollars per horsepower.

The estimated capital costs ($/hp) for a the purchase of new diesel engine was derived from actual costs for diesel generators installed in California and calling dealerships. Table I-3 lists costs of diesel generators of various sizes in California. This information was used to develop an equation relating the size of the generator to the cost. Figure I-2 graphically represents this relationship and the resulting trend line and equation in terms of total generator costs versus power output. These equations are used to calculate the values presented in Chapter IX.

Table I-3: List of New Diesel Generators Costs

Manufacturer	kW	HP	Price
Cummins	100	147	$ 16,000
Cummins	150	221	$ 20,000
Cummins	200	295	$ 28,000
Cummins	250	368	$ 33,000
Caterpillar	335	493	$ 50,000
Cummins	500	736	$ 62,000
Caterpillar	600	884	$ 90,000
Cummins	750	1104	$ 93,000
Cummins	1000	1473	$ 115,000
Cummins	1500	2209	$ 183,000
Cummins	2000	2945	$ 248,000
Caterpillar	2000	2945	$ 288,000
Caterpillar	2000	2945	$ 311,380

Figure I-2: New Generator Costs in California



Based on this regression, we estimate the costs for new diesel generators to be approximately $92.65 dollars per horsepower.

II. Summary of In-use Diesel Fueled Stationary Engine Population and Costs

Table I-4 summarizes the stationary in-use diesel engine statistics and associated costs. Data for both private and public engine ownership is provided. The public engines are further subcategorized by local, State, and federal owned. The numbers in this table with parenthesis around them are negative values representing cost savings. All the values are combined emergency standby (E/S) and prime engines unless otherwise indicated.

Table I-4: Population and Cost for In-Use Diesel-Fueled Engines

Category	Summary of Total In-Use Engines					
	All	Private	Public	Local	State	Federal
State Wide Installation Cost ($)	$ 45,990,000	$ 35,950,000	$ 10,740,000	$ 6,350,000	$ 750,000	$ 3,640,000
Annual Maintenance & Fuel Cost ($)	$ (52,000)	$ 691,000	$ (32,000)	$ 4,000	$ (100,000)	$ 41,000
Annualized Cost ($)	$ 7,757,000	$ 6,672,000	$ 1,511,000	$ 1,025,000	$ 13,000	$ 632,000
Annualized E/S Cost ($)	$ (679,000)	$ 33,000	$ (99,000)	$ (36,000)	$ (97,000)	$ 14,000
Annualized Prime Cost ($)	$ 8,437,000	$ 6,640,000	$ 1,610,000	$ 1,062,000	$ 109,000	$ 619,000
# of Engines retrofitted	1,559	1,211	348	212	26	109
# of E/S Engines retro	232	167	65	45	9	12
# of Prime Engines retro	1,327	1,044	283	167	17	98
Population of Engines	20,987	10,796	10,191	5,600	899	3,692
Pop. of E/S Engines	19,660	9,752	9,908	5,432	882	3,594
Pop. of Prime Engines	1,327	1,044	283	167	17	98
Local Ann. Cost Inspect	$ 378,500	$ 226,300	$ 152,100	$ 84,600	$ 12,800	$ 54,700

III. Statewide Annual and Total Costs for Businesses

Table I-5 presents the estimated statewide costs to business having prime and emergency standby engines. The categories are in-use emergency standby and prime, new emergency standby and prime, and new agriculture.

Table I-5: Statewide Annual Costs

Equipment Category		Total Capital Cost ($)	Annualized Capital Cost ($)	Annual Recurring Costs ($)	Total Annualized Cost ($)
In-use	Prime	$ 33,652,844	$ 5,965,565	$ 674,066	$ 6,639,630.00
	E/S	$ 2,296,060	$ 162,911	$ -130,132	$ 32,779
New	Prime	$ 529,765	$ 75,427	$ 417	$ 75,844
	E/S			$ 7,431	$ 7,431
	Agriculture			$ 2,120	$ 2,120
Total		$ 36,478,669	$ 6,203,902	$ 553,902	$ 6,757,805

IV. Stationary Prime Diesel Engines Assumptions

Table I-6 lists the statewide in-use prime engine information used as the basis for calculating the costs and PM emissions. For in-use prime engines, 80% of the engine population is assumed to be retrofitted with an 85% emission reduction device, while the remaining 20% are assumed to retrofit their engines to meet a 30% emission reduction and then purchase a new engine meeting Tier IV requirements in 2011. For example, for 50-175 horsepower, low use engines shown in Table I-6 below, 169 of 211 engines are expected to be retrofitted to achieve an 85% reduction, and 42 are expected to be retrofitted to achieve a 30% reduction, with and engine replacement in 2011.

Table I-6: Statewide In-use Prime Engine Size, Use, and PM Emissions Rate Characteristics

State Inventory =	**1327**	**2002 inventory DEPICT**						
Prime Engines								
HP Range	0-500 hrs =Low Use or 500+ =High use	# Engines	Avg. Size (hp)	Load	Avg. Annual Hours	Current PM (g/bhp-hr)	New PM (g/bhp-hr)	Reduction Required
50-175	Low Use	169	127	0.50	103	0.55	0.0825	85%
50-175	Low Use	42	127	0.50	103	0.55	0.385	30%
50-175	Low Use	42	127	0.50	103	0.55	0.01	New Eng after 2011
50-175	High Use	115	118	0.32	1246	0.5	0.075	85%
50-175	High Use	29	118	0.32	1246	0.5	0.35	30%
50-175	High Use	29	118	0.32	1246	0.5	0.01	New Eng after 2011
175-750	Low Use	230	321	0.61	132	0.38	0.057	85%
175-750	Low Use	57	321	0.61	132	0.38	0.266	30%
175-750	Low Use	57	321	0.61	132	0.38	0.01	New Eng after 2011
175-750	High Use	264	413	0.45	1519	0.38	0.057	85%
175-750	High Use	66	413	0.45	1519	0.38	0.266	30%
175-750	High Use	66	413	0.45	1519	0.38	0.01	New Eng after 2011
750+	Low Use	47	1187	0.49	71	0.3	0.045	85%
750+	Low Use	12	1187	0.49	71	0.3	0.21	30%
750+	Low Use	12	1187	0.49	71	0.3	0.01	New Eng after 2011
750+	High Use	237	1492	0.60	2168	0.3	0.045	85%
750+	High Use	59	1492	0.60	2168	0.3	0.21	30%
750+	High Use	59	1492	0.60	2168	0.3	0.01	New Eng after 2011

V. Stationary Emergency Standby Diesel Engines Assumptions

Table I-7 lists the statewide in-use emergency standby engine information used as the basis for calculating the costs and PM emissions. As shown, the estimated PM emission rate varies with the age of the engine, and its horsepower rating.

Table I-7: Statewide In-use Emergency Standby Engine Population, Size, and PM Emissions Rate Characteristics

Model Year Range	Horsepower Range	# Engines	Average HP	Existing PM Emission Rate (g/bhp-hr)
Pre 1987	<=250	2597	140	0.55
Pre 1987	>250	3883	613	0.53
1988-2002	<=250	5177	131	0.38
1988-1995	250<=750	2456	416	0.38
1988-1999	>750	3149	1224	0.38
1996-2001	250<=750	1624	423	0.15
2000-2002	>750	709	1674	0.15
2002	250<=750	66	409	0.12

VI. Annual Cost Effectiveness

Table I-8 lists the estimated statewide annual costs, PM emissions reduced (based on the ARB emissions inventory), and resulting cost effectiveness. The figures are provided for 2005 through 2020, and vary with the implementation of the various regulatory provisions for different types of stationary diesel engines.

Table I-8: Statewide Annual Costs, PM Reduced, and Resulting Cost Effectiveness

Year	Sum Annual Costs ($)	Inventory Based PM Reduced	Cost Effectiveness	
		(tons/yr)	($/tons)	($/lb)
2005	$ 1,354,316	145	$ 8,043	$ 4.02
2006	$ 3,108,844	125	$ 20,391	$ 10.20
2007	$ 4,693,204	114	$ 32,388	$ 16.19
2008	$ 6,119,622	103	$ 44,179	$ 22.09
2009	$ 5,842,752	93	$ 44,416	$ 22.21
2010	$ 5,578,374	73	$ 51,459	$ 25.73
2011	$ 5,409,320	76	$ 45,996	$ 23.00
2012	$ 5,159,407	68	$ 46,636	$ 23.32
2013	$ 4,135,495	61	$ 39,895	$ 19.95
2014	$ 3,197,399	54	$ 33,069	$ 16.53
2015	$ 2,358,752	51	$ 24,349	$ 12.17
2016	$ 1,592,726	42	$ 19,248	$ 9.62
2017	$ 1,336,349	36	$ 17,636	$ 8.82
2018	$ 1,100,777	32	$ 15,999	$ 8.00
2019	$ 900,639	27	$ 14,566	$ 7.28
2020	$ 717,067	23	$ 12,874	$ 6.44
		Weighted Average =	$ 30,821	$ 15.41

Table I-9 presents another cost effectiveness based on the reduction in reactive organic gases (ROG) and oxides of nitrogen (NOx) combined. The total statewide annual costs were split evenly between PM and ROG+NOx, such that half of the total statewide annual costs were used along with the associated ROG+NOx reductions. As shown in Table I-9, the resulting cost effectiveness value of the years 2005-2020 is $0.92 per pound of ROGF+NOx reduced. The resulting PM cost effectiveness (which is not shown in Table I-9) is simply half the value presented in Table I-8, or $7.70 per pound of PM reduced.

Table I-9: Statewide Annual Costs, ROG and NOx Reduced, and Resulting Cost Effectiveness

Year	Sum Annual Costs ($)	Inventory Reduced			ROG+NOx Cost Effectiveness	
		ROG (tons/yr)	NOx (tons/yr)	ROG+NOx (tons/yr)	($/ton)	($/lb)
2005	$ 677,158	165	418	583	$ 1,162	$ 0.58
2006	$ 1,554,422	157	306	463	$ 3,358	$ 1.68
2007	$ 2,346,602	149	389	538	$ 4,360	$ 2.18
2008	$ 3,059,811	141	455	596	$ 5,131	$ 2.57
2009	$ 2,921,376	133	530	663	$ 4,407	$ 2.20
2010	$ 2,789,187	126	352	478	$ 5,839	$ 2.92
2011	$ 2,704,660	118	679	796	$ 3,396	$ 1.70
2012	$ 2,579,704	110	753	863	$ 2,989	$ 1.49
2013	$ 2,067,748	102	828	930	$ 2,224	$ 1.11
2014	$ 1,598,699	94	902	997	$ 1,604	$ 0.80
2015	$ 1,179,376	87	897	983	$ 1,199	$ 0.60
2016	$ 796,363	79	1,051	1130	$ 705	$ 0.35
2017	$ 668,174	71	1,126	1197	$ 558	$ 0.28
2018	$ 550,388	63	1,200	1263	$ 436	$ 0.22
2019	$ 450,320	55	1,275	1330	$ 339	$ 0.17
2020	$ 358,533	48	1,485	1532	$ 234	$ 0.12
Weighted Average =					$ 1,834	$ 0.92

VII. Impacts on Business

To comply with State law, ARB staff evaluated the impacts to a typical business and a typical small businesses. Our analysis is presented below.

Estimated Typical Business Impacts

Many businesses do not own any diesel-fueled stationary engines. Based on the ARB Survey, for those businesses that do have stationary diesel-fueled engines, the average business owns 2.5 emergency standby engines of 700 horsepower, or three prime engines of 560 horsepower.[1] The ARB survey of prime engines had a low response rate. The State inventory average prime engine size is 590 horsepower. Since the survey data and State inventory data are very close, the State inventory average prime engine size was used for the cost calculations.

[1] We believe this may be an overestimate of the number of engines owned by a typical business. Some of the telecommunication businesses own hundreds of engines, which may have biased the average.

According to the data collected, most businesses that own an emergency standby engine will not need to install DECS, and for those that do, the majority can use the less expensive diesel oxidation catalyst. The costs to a business with a typical size emergency standby engine could range from $250 to $16,750. The low end of the cost range reflects businesses that will not have to install retrofits (ie., no equipment cost). The upper end reflects businesses that will retrofit emergency standby engines with DOCs at an average capital cost $6,700 each. Because the average private business that owns an emergency standby stationary diesel-fueled CI engine has 2.5 engines, the potential capital cost to a business is estimated to be $16,750.

If a business owns a prime engine, that doesn't already meet the ATCM requirements, then retrofit with a DPF or DOC would be necessary. According to our survey, the average prime engine owned by a small business is approximately the same horsepower rating (540 hp) as a prime engine owned by a typical business (560 hp). Because this average is fairly close to the average horsepower of a prime engine owned by a small business, we used the overall average horsepower of 590 to simplify our cost analyses. This results in a conservative cost estimate. Therefore, the average capital cost to retrofit a prime engine ($19,200) is approximately the same for a typical business owning a prime engine or a small business owning a prime engine. Since a typical business owning a prime engine owns 3 of them and a small business owning prime engines has 1.75, the cost ranges from $57,600 to $33,600.

The annual ongoing costs are based on a reporting cost of $100 per engine per year and an estimated per-engine annualized cleaning cost of $1.33/hp engine size every 1,500 hours. This results in annual ongoing costs averaging $100 for emergency standby and $650 for prime per engine per year. Because the average business owns 2.5 emergency standby engines or 3 prime engines, the estimated recurring costs are $250 to $1,950 for businesses that own an emergency standby or prime stationary diesel engine(s).

Estimated Small Business Impacts

The cost to a typical small business is derived from the average size and number of engines owned. Most small businesses in California do not own any diesel-fueled stationary engines. Based on the ARB Survey, for those small businesses that do have stationary diesel-fueled engines, the average small business owns 1.5 emergency standby engines with an average horsepower of 500, and 1.75 prime engines, with an average horsepower of 540. The overall average horsepower for all prime engines reported in the ARB Survey was 590 bhp. Because this average is fairly close to the average horsepower of a prime engine owned by a small business, we used the overall average horsepower of 590 to simplify our cost analyses. Therefore, the average capital cost to retrofit a prime engine ($19,200) is approximately the same for a typical business owning a prime engine or a small business owning a prime engine. This results in a conservative cost estimate.

As with all businesses, most small businesses that own emergency standby diesel-fueled CI engines will not need to install DECS. However, the ARB Survey revealed that small businesses have a higher percentage of older and dirtier engines that may require a control device such as a DOC. Even though a small business emergency standby engine is slightly smaller than a typical business emergency standby engine, the increased age and emission rate may require a slightly more expensive DOC. Staff assumed that the average capital cost to retrofit an emergency standby engine is approximately the same for a typical business owning an emergency standby engine or a small business owning an emergency standby engine. This results in a conservative cost estimate. The costs to a small business with a typical size emergency standby engine could range from $150 to $10,200. The lower end of the range given for "emergency standby" reflects the small businesses with engines not requiring installation of DECS (no equipment cost, only reporting cost). The upper end of the range reflects capital and associated recurring costs for small businesses needing to retrofit 1.5 engines at a cost of $10,200 (average capital cost of $6,700 per engine plus $100 for reporting).

Any prime engine operated by a small business ,that doesn't already meet the ATCM requirements, would require installation of a DECS. Capital costs would range from $11,000 to $147,000. The average small business with a prime engine is expected to have initial costs of about $33,600 based on the average size and number of prime engines owned.

The annual ongoing costs are based on a reporting cost of $100 per engine per year and an estimated annualized DPF cleaning cost of $1.33 per horsepower engine size conducted every 1,500 hours. This results in reporting and cleaning costs averaging $100 for emergency standby engines and $650 for prime engines per engine per year. Because the average small business owns 1.5 emergency standby engines or 1.75 prime engines, the estimated costs range from $150 to $1,134 for small businesses that own an engine or engines. Table I-9 lists the costs identified in sections VII and VIII.

Table I-9: Estimated Typical and Small Business Retrofit Costs

Stationary Engine Category		Typical # of engines	Average Size	Recurring Costs	Capital Costs per Engine	Total Recurring Costs	Total Capital Costs
Typical Business	E/S	2.5	700	$ 100	$ 6,700	$ 250	$ 16,750
	Prime	3	590	$ 650	$ 30,100	$ 1,950	$ 90,300
Small Business	E/S	1.5	500	$ 100	$ 6,700	$ 150	$ 10,050
	Prime	1.75	590	$ 650	$ 30,100	$ 1,138	$ 52,675